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Abstract

Up to 20% of the electricity in Denmark comes from wind power and the goal is to increase the percentage. This puts great demand on the flexibility of the remaining energy system. In Denmark 27% of the waste produced in 2004 was incinerated mainly in CHP plants delivering power as base load. In order to increase the flexibility of the system a project is analysed, were waste is gasified and then used either for heat and power production or for bio-fuel production depending on the price of electricity. A national energy system analysis of the technology is carried out using the deterministic simulation model, EnergyPLAN, developed at Aalborg University.

The analysis shows that the gasification project shows great potential with regards to saving fossil fuel when the syngas for combined heat and power production and it provides the cheapest CO2 reduction when used for transport fuel, compared to other waste handling alternatives.

Context

In the EU, municipal waste is, at present, disposed of through landfilling (49%), incineration (18%), and recycling and composting (33%) [1]. The EU has, however, introduced aims which significantly reduce the amounts of biodegradable waste, which may be landfilled. According to these aims, the amount of biodegradable waste deposited at landfills must not in 2014 exceed 35% of the amount of biodegradable waste produced in 1995 [2]. Consequently, at the EU level, great efforts are made to identify alternatives to landfilling of biodegradable waste.

Recent aims of the European Union show an increase in the level of renewable energy in the EU as a whole from less than 7% today to 20% by 2020 and a minimum of 10% bio-fuels [3]. The utilization of waste for energy can contribute to these goals.

Technical description

A new research project named “Renewables, Science and renaissance of the energy system” in short “REnescience” is used as case for the analysis. The purpose of the project is to develop and verify a technology for flexible and integrated production of electricity, heat and synthetic petrol through gasification of biomass/waste together with coal. [4]

Household waste will enter the pretreatment plant unsorted. Then the waste will be liquefied using heat and enzymes and run over a sieve to sort out non-liquefied parts to be incinerated or reused. Subsequently the liquefied mass will be gasified. Two different gasification technologies will be tested: Gasification with coal in an entrained flow gasifier under high pressure (up to 400

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bar) and high temperature (1700ºC) and supercritical wet gasification, which occurs in water under supercritical condition.

The produced syngas will be used either for CHP production when the electricity price is high (and the wind power production low), or for producing petrol, when the electricity price is low. Petrol will be produced with a catalytic process which was originally developed for conversion of natural gas under a constant flow. The process will now have to be adapted to conversion of syngas with varying flow.

One advantage of the plant is that the gasification process will run continuously independent of the electricity prices, which results in a better economy of the entire plant.

Innovation relevance

One of the innovative features of the project is that a 2nd generation bio-fuel is produced, which does not use food but rather waste to produce bio-fuel.

The project has two main focuses. The first is on development of the pretreatment of the biomass and waste through liquefaction. Liquefaction is cheaper than mechanical treatment, but the cost of enzymes is an important factor, which has to be kept down. Furthermore, the project has focus on the catalytic process. In particular it is important to develop a process, which can handle variations in load.

Current results

In the analysis, the project is split up into two alternatives: one of gasifying waste and subsequently using it for CHP (Syngas CHP) and one of using the gas to produce bio-fuel (Syngas Transport).

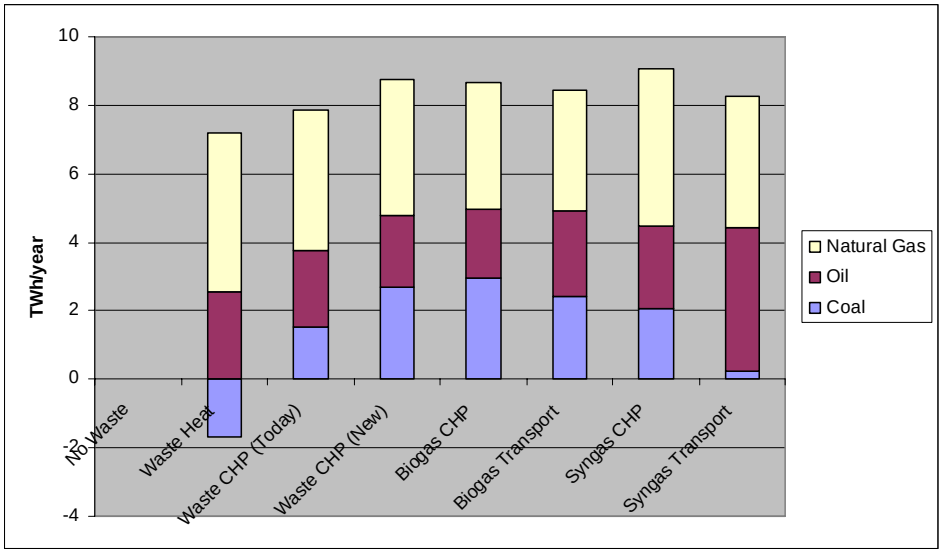

Figure 1 Fossil fuel substituted when utilizing 10 TWh waste per year. Including 2.5 Mt manure for biogas and 3 TWh coal for syngas

The alternatives are compared to not using waste for energy (No Waste), using the waste for heat alone (Waste Heat), incinerating waste in existing CHP plants (Waste CHP (Today)) or new CHP plants (Waste CHP (New)) or producing biogas through anaerobic digestion and using the biogas for CHP (Biogas CHP) or for transportation in natural gas cars (Biogas Transport). The comparison shows, that the Syngas CHP alternative saves most fossil fuel, and the Syngas Transport alternative saves most oil. (See figure above)

The analysis also shows that when considering the amount of CO2 emitted from the Danish energy conversion sector, the biogas alternatives saves most CO2.

Considering the costs, the Syngas Transport scenario has the lowest CO2 reduction costs, however, since gasifying waste to produce bio-fuel is still at an experimental stage, the costs are attached with a high degree of uncertainty.

The full results of the analysis together with explanation of the methodology and data behind the analysis can be found in [5].

Future perspectives

The project used as case is designed to be built at a central waste incineration plant with CHP production. However, the project may still show great perspective for EU nations, which are currently focusing on finding alternatives to landfilling their biodegradable waste and which are interested mainly on producing electricity and bio-fuels or bio-fuels alone.

With the current lay-out, the process necessitates use of coal at a scale of 3/1 to waste. In the future it may be possible to gasify the waste together with biomass, which would improve the CO2 reductions considerably and make the produced bio-fuel more sustainable.

Conclusions

Gasifying waste and using it for CHP or bio-fuel production has a great perspective and potential for reducing import of fossil fuels and increasing the flexibility of the energy system thereby facilitating a higher degree of renewable energy in the remaining energy system.

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